INDUSTRIAL HYGIENE

The Science, the Law and the Economics of Industrial Health

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Informing the Worker

MANY textbook dissertations on occupational disease control include the direction that the worker should be informed that he is exposed to the hazard under consideration so that he may observe the proper safeguards. At first glance, this advice appears desirable and almost to go without saying. Labor interests certainly accept the idea as axiomatic. But the employer, and those advising him, often follow up the initial acceptance of a plan which involves informing the worker with a number of misgivings, and come to the conclusion that the less said about any health hazards incident to operations the less trouble will ensue.

Let us review the reasons brought forward to lead to this latter conclusion, examine their cogency, compare them with experiences where the workers have been informed, and, finally, on this broader basis arrive at a more mature viewpoint on this subject. It is to be noted that, with increasing emphasis being placed upon the industrial relations aspect of industrial hygiene, this matter is assuming constantly greater importance.

PROBABLY the first thought that occurs to those charged with the smooth handling of industrial relations is that informing the worker about the health hazards to which he is exposed will cause him to be over-apprehensive, will stimulate him to make compensation claims for occupational disease, and, worst of all under present tight labor markets, will lead him to seek employment elsewhere.

Not only is it alleged that such undesirable results will occur but, in addition, that labor unions will include in subsequent contracts supplementary wage rates to compensate the worker for subjecting himself to conditions which may cause injury to his health. And besides, there is the psychological factor such as occurs after one has just finished reading the home doctor book or the patent medicine ad—we have more symptoms than we had previously known existed.

What has actually been the experience where the worker has been informed concerning the presence of potential health hazards? There is no question but what examples of all of the undesired results referred to have occurred and could be brought forward in support of the contention that the worker should be kept in the dark. It is accordingly in order to point out that there are good and bad methods of handling such a matter, and furthermore that much depends upon the modern concept of quantities of injurious materials as being an all-important fact.

In informing the worker that he is exposed to dust, it is obviously not the thing to do to tell him that he is to be working with dust containing silica and that, if he doesn't wear his respirator, he will get silicosis and die. The proper method involves a discussion of the amounts of dust which may be injurious.

With facilities available today, any plant including exposure to dust with a quartz or other free silica content should know the concentrations of dust in the air at the various operations. In all probability conditions which normally cause continued exposure to sufficiently large amounts of dust to result in silicosis have, for the most part, been brought under control. But it is essential that the cooperation of the worker be enlisted so that he may avoid unnecessary high exposures, or so that he will wear a respirator during certain parts of the operation where the dust may be difficult to control economically.

A recommended procedure in such a case is that the man be told that breathing too much of this dust over five or 10 or more years may affect his breathing capacity, with the development of a condition known as silicosis; that, if he does not breathe unnecessarily large amounts of this dust, he may continue at the job all his life without any effect on his lungs; that management has made very sure that the condition is safe by having dust determinations made which have shown that the average amounts of dust in the air are within safe limits when the job is properly conducted by the worker; that such details as avoiding careless handling of air jets in dusty areas be observed; that certain parts of his operations, which are specified, require wearing a respirator furnished by the employer and approved by the U. S. Bureau of Mines; and that, in addition to routine checks of the amount of dust in the air, the company takes periodic x-rays of the chests of all workers exposed to dust in order to learn whether the

individual method of operation might be involving more of a dust exposure than expected and bring this to management's attention for further corrective measures before silicosis actually developed.

Questions should be encouraged, as they permit various misconceptions concerning the effects of dust to be dispelled. A commonly-believed fallacy is that inhalation of dust leads to tuberculosis; another, that a man who enters the stone-cutters' trade will die at the end of 10 or 20 years because his lungs will, by that time, have become filled with stone dust.

The road between unjustified hysteria over an occupational disease hazard and a dangerous indifference to its effects takes the direction of a simple explanation, *with strict adherence to the exact truth in the light of present knowledge.*

Where the worker has been informed concerning the health hazards of his job along some such lines as in the foregoing example, always with emphasis on the fact that it is an excessive exposure which can be quantitatively evaluated that is to be avoided, with variations in approach and in detail to meet the seriousness of the hazard and the level of intelligence and the personality of the worker—when this matter is handled in this manner, what of the validity of the objections which have sometimes been raised by management?

I T HAS been our experience that apprehensiveness has usually been either due to a history of actual cases of occupational disease produced under uncontrolled conditions or has been the result of exaggerated stories with little basis in fact. We have been told by a hardrock tunnel worker, all in good faith and with the air of letting us in on some inside information, that a friend of his worked for just 10 days on the Gauley Bridge tunnel and breathed so much quartz dust in that time that he forthwith died of silicosis. The best antidote to over-apprehensiveness is a matter-of-fact account of the actual situation.

Claim consciousness among a group of exposed workers may cost the insurance company—and eventually, through increased rates, the employer—greatly more than the anticipated losses. It is consequently something that every good lawyer will advise be not unnecessarily stimulated. Where one has observed a claimant on the witness stand glibly reciting his symptoms as rehearsed from the book, one is likely to conclude that the more the worker is informed the more vulnerable his employer becomes if for any reason at all the worker decides he will institute a claim.

Without suggesting for a moment that the man with a true occupational disease should not be compensated, the inclusion, in the discussion about the potential hazards, of the fact that the employer has complete information on the severity of the exposure at his plant, and on the amounts of the hazardous material required to cause injury to health, together with information concerning the development of any effect on the health of the individual as shown by physical examination, x-rays, blood tests, etc.—the inclusion of this fact tends to discourage any preconceived ideas on the part of some smart worker that, as employment and wages may start to drop, he might look for employment in a plant with a known health hazard, work there for a brief period, and then feign the symptoms of the occupational disease to which he might claim he was exposed.

Today, workers tend to know that certain of the materials with which they are working may cause injury. The reluctance of the employer to give them the straight facts about these encounters almost the same situation as that of the reluctant parent who finds that his 10 or 12 year old child already is well informed on the facts of life but that owing to the source of the information, the facts are grossly distorted.

T HE plants where real efforts have been made to control health hazards have had no exceptional difficulties in holding their employees even under the labor shortages of the past several years, although the employees have been completely informed about health hazards. There is probably no material which is more extensively known as an insidious poison than radium, and especially as applied to the dial-painting industry. But even this industry, which has given meticulous attention to reducing exposures to levels below those which are known to cause injury, has had no exceptional difficulties in attracting and holding a far greater number of workers than ever before in its history. All these workers are well informed on the hazards of the radium paint, but they have confidence in the sincerity of their employers to institute proper safeguards for the protection of their health.

And as for the imposition of an additional increment in wage rates for presence of an occupational disease hazard, it would seem that here again the relative exposure of the hazard should be the deciding factor. If a worker is required to handle some very poisonous material, it is to his greater personal interest that money be spent to reduce his exposure to a level where his health will not be injured than that the exposure remain excessive and he receive a higher wage.

It is of interest that in one recent case, failure to obtain and pass along to the labor union competent advice concerning the effect of a material on health resulted in an additional 11 cents on the hourly rate. In this case the labor union contended that the dust from glass wool insulation as it was applied to ships would cause injury to the lungs of the carpenters assigned to this job. The employer considered this was reasonable. After all, didn't everyone know that glass wool dust caused your skin to itch where the tiny fibers became imbedded in the skin? And how much more the delicate, soft lung tissue would be injured! The fact is, of course, that dust from glass wool is not injurious to the lungs—as any competent authority would have informed this employer, the labor union, or the carpenters who were assigned to the job.

I T IS NOT suggested that the worker need be given minute details concerning all the symptoms which each hazardous material may cause. Carbon monoxide produces headaches, but there are many other causes, non-occupational as well. But it is considered desirable that the worker tell his foreman of any symptoms which might be referable to the exposure. The foreman should in turn, inform the plant medical department. It occasionally happens that early symptoms may point to some unexpectedly high exposure and permit its correction before serious injury develops. On the other hand, if an occupational cause for a symptom can be ruled out, then the worker has just that much better opportunity to obtain a correct diagnosis and proper medical treatment.

The present trend is toward informing the worker about the materials he is to encounter and his part in avoiding excessive exposures to them. The industrial concerns which make a practice of so informing their workers are on the increase. And so far as we have been informed, where the quantitative aspects of the exposures are included in the discussion there have been none of the disadvantageous results over which apprehension has so often been expressed.

In fact the desirability of informing the worker about the results of his x-ray findings is also on the increase and has marked advantages, as so ably discussed by DR. L. E. HAMLIN in the March, 1945, INDUSTRIAL MEDICINE. And, as was brought out by DR. HAMLIN, *the informer should himself be well-informed.*

The Safe Use of Solvents for Synthetic Rubbers

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THE invasion by Japan of those areas of the Orient which supplied the United States with most of our natural rubber has reduced our imports of this material almost to the vanishing point. Rubber used in this country at present consists of that natural rubber which was part of our stockpile when the war began, the small amount of natural rubber still being imported from Ceylon and South America, the very small amount of guayule and similar rubbers raised in Mexico and the United States, plus reclaimed natural rubber and synthetic rubber now being made in this country.

Five principal types of synthetic rubber are now manufactured and used in the United States:

1. The first to be made in commercial quantities was Neoprene, polymerized chloroprene.

2. The second to appear were the Thiokols. The Thiokols are polymerized condensation products of sodium tetrasulfide and chlorinated compounds such as ethylene dichloride, propylene dichloride, and dichlorethyl ether.

3. Buna S was developed to take the place of natural rubber, especially for the manufacture of rubber tires. Buna S is a co-polymer of butadiene and styrene. This rubber is now being manufactured in quantity approximately equal to the total tonnage of natural crude imported into this country before the war.

4. Butyl rubber, which is the easiest of all the five synthetic rubbers to prepare, sometimes known as horse-trough or bathtub rubber, is a co-polymer of butadiene and isobutylene.
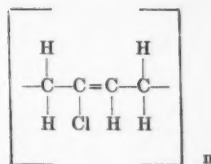
5. The fifth type of rubber is Buna N, a co-polymer of butadiene and acrylonitrile or vinyl cyanide. Buna N was developed by a number of manufacturers in this country and is often known under such tradenames as Perbunan, Hycar, Chemigum, Thiokol RD, and Ameripol.

The physical and chemical properties of these five types of synthetic rubbers are dissimilar, and hence rubber products may now be made from that particular type of rubber whose properties are most nearly those desired in the final product.

A portion of this paper was presented before the Rubber Section, 32nd National Safety Congress, Chicago.
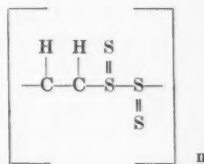
Neoprene

NEOPRENE, which is ——→ is highly resistant to the action of petroleum hydrocarbons. It was first used in the manufacture of hose and fittings designed to come in contact

with petroleum oils and certain other solvents which may soften or swell natural rubber but do not affect neoprene to the same extent. It has also been used largely in the form of a cementing material in the manufacture of some of the earlier types of self-sealing gasoline tanks for military and naval airplanes. Neoprene is readily attacked by the aromatic hydrocarbons and many of the chlorinated hydrocarbons. Some of these substances are such good solvents for neoprene that they may be used for the manufacture of neoprene cements. Smaller quantities of solvents, such as acetone, ethyl acetate and other solvents usually found in lacquers (e.g., butyl acetate) are being used in combination with better neoprene solvents in the manufacture of neoprene cements. Also used as solvents are the aromatic petroleum naphthas type I such as Solvesso No. 1, Sovasol No. 73, Union No. 8, and Amsco A. These are essentially mixtures of toluene and petroleum naphtha. The higher boiling aromatic petroleum naphthas which are combinations of xylene with petroleum naphtha may also be used. Cyclohexane and other naphthenes have also been found as constituents of neoprene cements.

Thiokols

GENERALLY speaking the Thiokols are produced by the interaction of sodium tetrasulfide with a chlorinated compound. For example, Thiokol A is produced by the action of sodium tetrasulfide on ethylene dichloride with subsequent polymerization to form:

The Thiokols are generally insoluble in most solvents including the aromatic hydrocarbons. Their greatest use arises from this property. Thiokols have been used for the manufacture of gasoline and oil hose, ink rolls for the printing industry and

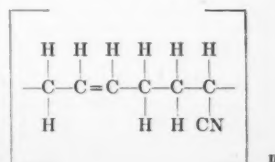also for the lining of tanks to be used for the storage of solvents.

Special Thiokols with modified properties can be made by proper selection of the chlorinated compound which is to be acted upon by the sodium polysulfide. Thiokols which show solubility have been used with ethylene dichloride and with methyl ethyl ketone as solvents for the lining of jettison gas tanks to be carried by aircraft and also for the building of large, subterranean gasoline storage tanks. These linings resist even the aromatic gasolines of high anti-knock rating which are sometimes used for aviation fuel. We have found a small percentage of chlorbenzene used with ethylene dichloride in Thiokol spreading compounds.

Buna N

BUNA N is a co-polymer of butadiene and acrylonitrile, whose formula is:

This type of rubber is also highly resistant to aromatic gasolines. It is however, very soluble in methyl ethyl ketone, in ethylene dichloride, and in propylene dichloride. Ce-
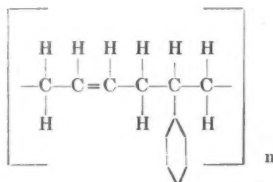
ment made by mixing Buna N with one or the other of these solvents are produced and used mainly for the manufacture of self-sealing gasoline tanks and products of similar nature. In the fabrication of self-sealing gasoline tanks one occasionally sees the solvent itself being used to render sheets of Buna N "tacky" so that they may be made to stick together, especially where this is merely the overlap of an edge or the corner of a tank.

Buna S

BUNA S is a co-polymer of butadiene and styrene. Its formula is:

Buna S at present is used chiefly for the manufacture of tires and other objects where the properties most nearly resembling natural rubber yield the desired results.

$$-C-C=C-C-C-C-$$

Until recently, Buna S was little used in solution form since cements formed of this rubber give little bonding strength. However, the use of Buna S in cements has increased more recently. These cements are used where positioning rather than strength of bond is desired, for example in the cementing of linings in shoes.
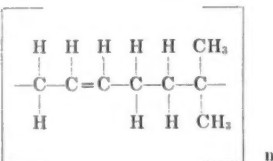
Butyl Rubber

BUTYL rubber, which is a co-polymer of butadiene and isobutylene, has the following formula:

This rubber requires the least amount of equipment to produce in commercial quantities. However, some of its properties, especially the physical properties, are less desirable than those of the previously enumerated four synthetic rubbers. It is probable that when the war ceases and natural rubber is again available, uses for this rubber will be found which depend more on its excellent impermeability to gases rather than on its physical strength. However, today it can be used as a diluent for natural rubber, and with reclaimed rubber in the manufacture of materials where great tear strength is not required.

Butyl rubber is soluble in petroleum naphtha and, therefore, may be used with this solvent to form spreading compounds which can well be used for coating fabric to produce gas-impermeable cloth.*

Solvents for Synthetic Rubbers

TABLE I lists the solvents which are used most frequently with the synthetic rubbers and the concentrations which, in our opinion, should be the maximum to which any worker should be exposed for the average working day of eight hours. These figures are not necessarily identical with those published elsewhere but they are, we believe, based on the best data available at the present time. The figure given for benzol is somewhat lower than that generally accepted[1] but we have found that this figure for benzol is none too low since intoxication can occur and has occurred when persons are exposed to a benzol concentration even as low as 50 parts per million. On the other hand, the figure for toluene is twice that usually given.[2] This figure is based on a field study made by

*The formulas for the synthetic rubbers given here are merely representative, since there are variations in composition in some of the types as well as in degree of polymerization.

TABLE I.
SOLVENTS USED WITH SYNTHETIC RUBBERS

Solvent	Used With	Suggested Approximate Maximum Permissible Concentration for Prolonged Exposure
Petroleum Naphtha	Buna S, Butyl	1.000 p.p.m.
Benzol	Neoprene	50
Toluol	Neoprene	400
Xylol	Neoprene	200
Trichlorethylene	Neoprene	200
Carbon Tetrachloride	Neoprene	75
Ethylene Dichloride	Thiokols, Buna N	100
Propylene Dichloride	Buna N	100
Methyl Ethyl Ketone	Thiokols, Buna N	500

the New York State Department of Labor in which more than 100 men exposed to toluene vapor were examined and in which the toluene content of the environmental air which they respired was determined by analysis.[3] This study is, we believe, the most complete yet made of the effects of toluene vapor on humans. For carbon tetrachloride, the figure usually cited in the literature is 100 parts per million.[1] However, recent studies by our Department[4] and confirmed by the Division of Occupational Hygiene of the State of Massachusetts[5] indicate that this figure is on the high side. For ethylene dichloride the figure presented of 100 parts per million is that cited by Dr. J. H. Sterner, of the Eastman Kodak Company.[6] Dr. L. R. Daniels, of the Hood Rubber Company of Watertown, Massachusetts, has found that ethylene dichloride vapor in concentrations down to 80 parts per million produces subjective symptoms of intoxication.[7] It is probable that the maximum permissible concentration for ethylene dichloride should be reduced, probably to the same figure given for carbon tetrachloride. There are at present no reliable data with which we are familiar on the maximum permissible concentration of propylene dichloride vapor. However, it is likely that propylene dichloride acts in a manner similar to ethylene dichloride and that the figure for the latter material may, with caution, serve for propylene dichloride.

Too much dependence should not be placed on the use of any of the maximum permissible concentrations for prolonged exposures. Many factors enter into the picture which do not allow for as great a simplification as the use of such figures would indicate. Unfortunately, many of these figures are based on limited data, in some instances only a single set of observations. Many, perhaps even hundreds of observations are required before reliable figures can be set. Moreover, individuals are not all similarly constituted. Where 100 parts per million of benzol, for example, may be safe for some individuals, death may occur with exposures to only 25 parts per million, and at least one such case has been observed. Some individuals may work at a higher rate of energy output at times than others with a consequent increase in rate of respiration. A person breathing at a greater rate than another will absorb a larger amount of atmospheric contaminants in a given period of time. Additional hours of labor and such factors as age, possibly sex, fatigue, indulgence in alcoholic beverages, taking of drugs or medication may all influence the toxic effects which a substance may produce on the human organism.

The problem of mixed solvents also arises and one frequently finds several solvents together in a single preparation, or several solvents being utilized in one workroom, so that employees are subjected to vapors of two or more materials simultaneously. In such cases, it is difficult to evaluate the additive toxic effects of the solvents, and therefore it is difficult to decide what

limits shall be placed on the concentration of each material separately. There is no justification for saying that the toxic concentration of each solvent shall remain stationary in the presence of other solvents. If such a statement were true, one would permit the maximum concentrations of all of the solvents listed in the table to be in the air simultaneously. It is obvious that the presence of additional solvent vapors adds to the discomfort and possibly to the intoxication of the employee.

The best guide to intoxication is, probably, complete medical examinations of the workers at regular intervals. How short those intervals shall be depends on the nature of the solvent employed. With benzol, carbon tetrachloride and possibly ethylene dichloride, hematological and medical studies made as often as once a month are not too frequent. One must be familiar with the earliest signs of intoxication. We have found that macrocytosis, increase in the average size of the red corpuscle of the blood, is one of the most reliable indications of early intoxication for benzol[8] and toluene. Dr. J. H. Foulger, of the Haskell Laboratory, has found that a decrease in blood pressure is a general indication of early intoxication.[9] A valuable procedure is to keep a continuous record of blood counts on each individual and be guided by changes which take place from the established levels for that individual.

In spite of the fact that maximum permissible concentrations for various solvents cannot be used as exact criteria of safe working conditions, they are nevertheless very helpful, especially in the design of ventilation equipment for maintaining safe working conditions.

The problem of protecting workers in industry from solvents used in connection with the synthetic rubbers resolves itself into two fairly separate problems.

The first of these is the problem of protecting the workers from acquiring dermatitis due to the action of the solvent on the skin. In the synthetic rubber industry solvents are not usually used by themselves, but rather in combination with the synthetic rubbers which may and often do contain accelerators, vulcanizing agents, anti-oxidants, fillers, loading materials, etc., present in the form of a cement or spreading compound. The problem of protection from dermatitis due to solvents is then similar to that of protection from the cement or spreading compounds and is largely a question of preventing contact between the substance and the skin of employees susceptible to these materials.

The second problem in connection with the safe use of solvents in the synthetic rubber industry is the prevention of the inhalation of vapors in concentrations sufficient to cause occupational disease, or sufficient to act as mild anaesthetics so that workers are made more prone to accident, or even in concentrations sufficient to be obnoxious to the worker.

PROTECTING THE HEALTH OF THE WORKER—SAFE USE OF SOLVENTS—There are three methods of approach to the problem of protecting the worker against toxic concentrations of solvent vapors. These three methods are commonly used throughout the field of industrial hygiene and have application in the present instance. They are:

1. Substitution of less toxic solvents.
2. General ventilation, i.e., dilution of the general workroom atmosphere with uncontaminated air.
3. Local exhaust ventilation.

Examples of the application of each of these methods will be discussed briefly.

Substitution

THERE is, of course, the possibility of the use of substitutes which are non-toxic or relatively less toxic than solvents now in use. Unfortunately, this technique does not lend itself so readily to the problem of the synthetic rubbers, for as indicated earlier, each of these rubbers is soluble in only a limited number of solvents.

We were involved in the problem of safeguarding the health of some 200 workers engaged in making fuel cells wherein benzol was extensively used as a solvent for neoprene. Fortunately this occurred at a time when toluene was still readily available. We were able to recommend an immediate change to the use of toluene instead of benzol without waiting for the installation of proper ventilation. The problem of the use of benzol with synthetic rubbers now arises only in the use of synthetics soluble only in the aromatic hydrocarbons and when toluene is not available. However, here too it may be possible to find suitable solvents containing no benzol for use with the synthetic rubbers usually requiring aromatic hydrocarbon solvents.

Later models of self-sealing gasoline tanks for aircraft were designed for use with aromatic gasolines containing as much as 40% aromatics. Neoprene could not be used in the cementing of such fuel cells. Buna N under one or another of its trade names then began to be largely used in the manufacture of such fuel cells.

Buna N is soluble in methyl ethyl ketone, ethylene dichloride and propylene dichloride. Methyl ethyl ketone is much less toxic than either of the other two solvents mentioned although its odor is such as to nauseate some employees who inhale its vapors. Once such susceptible persons are removed from the immediate vicinity of methyl ethyl ketone vapors, the remaining employees should have no difficulty with this solvent in concentrations as high as 500 parts per million, whereas ethylene dichloride or propylene dichloride may be troublesome in concentrations as low as 100 parts per million and possibly even lower. It is true that methyl ethyl ketone is more inflammable than ethylene or propylene dichloride. However, each of the other two solvents has a flashpoint below room temperature.

We have seen methyl ethyl ketone used with Buna N in the manufacture of self-sealing tanks with great success. We have, however, been in plants where ethylene dichloride and propylene dichloride are used and on inquiry have learned that these plants would not employ methyl ethyl ketone, even though its toxicity is lower, because it was found that methyl ethyl ketone would not give as satisfactory a cement or was considered too inflammable for use.

The most recent cases we have encountered of the use of benzol in synthetic rubber cements have been in the manufacture of shoes. Until rather recently, natural rubber cements had been used. As the supply of this material dwindled, synthetic rubbers were released for such use: neoprene where strength of bond was required, and Buna S where positioning alone was sufficient. We have found benzol in both types of cements—unnecessarily, since Buna S will dissolve in petroleum naphtha alone, and neoprene can be dissolved in one of the aromatic petroleum naphthas which contain petroleum naphtha and an aromatic hydrocarbon which is less toxic than benzol, that is, either toluene or xylene.

General Ventilation

IN THE fabrication from synthetic rubber of certain large articles, large floor areas and hence large room

Fig. 1.
General ventilation used in cementing operations on self-sealing fuel cells. Air is exhausted through grill in floor shown in foreground. Air inlets not shown

Fig. 2.
General ventilation used in cementing operations on self-sealing fuel cells. Air inlets are shown along ceiling

Fig. 3.
General ventilation used in cementing operations on rubber life rafts. Air is exhausted through grills in floor and admitted through distributors along ceiling

Fig. 4.
General ventilation used in cementing seams on barrage balloons. Large room volume provides for initial dilution of solvent vapor. Mechanical ventilation provides necessary air change

volumes are required. In such cases considerable dilution of vapors may take place so that toxic concentrations are not built up in the workroom air. Dilution due to the large volume of room air which is present may be increased by the use of generalized ventilation in which additional air is brought into the room at the ceiling level and removed through the workroom floor.

TABLE II.
GENERAL VENTILATION REQUIREMENTS

Solvent	Suggested Approximate Maximum Permissible Concentration For Prolonged Exposure	Volume of Air Required for Dilution of Vapor from One Gallon of Solvent so that Concentration of Solvent Vapor is equal to Suggested Maximum Permissible Concentration in Column 2
Petroleum Naphtha (as hexane)	1,000 p.p.m.	25,000 C. F.
Benzol	50	700,000
Toluol	400	75,000
Xylol	200	135,000
Trichlorethylene	200	185,000
Carbon Tetrachloride	75	435,000
Ethylene Dichloride	100	400,000
Propylene Dichloride	100	335,000
Methyl Ethyl Ketone	500	75,000

Table II indicates the quantity of air which must be brought into a room to be provided by existing room volume to dilute a gallon of each of the solvents listed to the maximum permissible concentration in air listed by us (Table I) when that gallon of solvent is completely evaporated. This is, however, predicated on uniform and complete homogeneity of atmosphe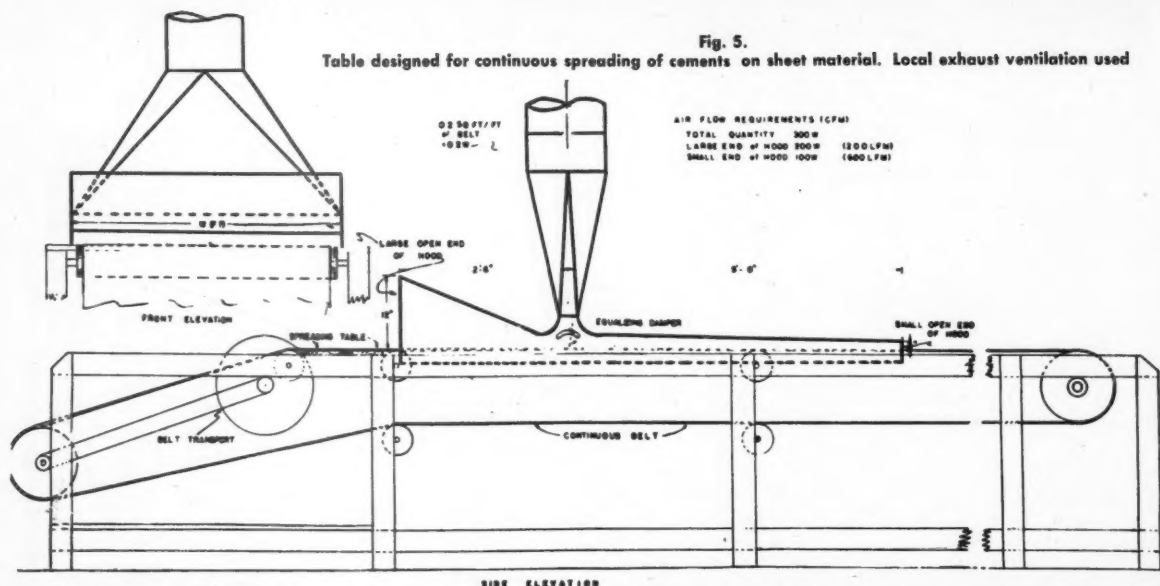ric concentration of the solvent vapor. This is usually difficult to attain, and vapor concentrations in the vicinity of workers using the solvents are as a rule higher than in areas of low activity. For this reason a larger volume of air than indicated in the table should be used for proper dilution.

There are several practical limitations to the quantity of air which can be used for general ventilation. One of these depends on the heating of workrooms. Air admitted to replace air exhausted from a workroom must be heated in winter weather sufficiently to bring the air from its outdoor temperature to a comfortable working temperature. Since the specific heat of air is approximately 0.25 B.T.U. per cubic foot per degree F, the fuel cost may be considerable if large volumes of air are to be heated Another limitation on total quantity of air brought into a room is that of local drafts. Workers would not be asked to work in areas wherein the air velocity exceeds 200 linear feet per minute, but even lower air velocities may remove heat from the surface of a body too rapidly for comfort. If its relative humidity is sufficiently low, this may occur even if the moving air has reached the temperature of the room air as a whole.

Where relatively non-toxic solvents, such as petroleum naphtha or methyl ethyl ketone are used, it is often possible to use general ventilation in workrooms of fairly large size in maintaining the concentration of vapors at the comfort level. With more toxic solvents, local exhaust ventilation is clearly indicated.

Figs. 1, 2, 3 and 4 illustrate the use of general ventilation in the cementing of large objects. The solvents used in all these operations were those of low toxicity.

Fig. 5.
Table designed for continuous spreading of cements on sheet material. Local exhaust ventilation used

Local Exhaust Ventilation

THE technique most frequently employed by the industrial hygienist for the control of toxic solvent vapors is local exhaust ventilation. This technique is clearly indicated where vapors are toxic in nature and where the conditions of work make it impossible to achieve control by a simpler means.

Fig. 5 illustrates a spreading table which we helped design and test and which was found satisfactory for use with toluene-containing cements to be brushed on
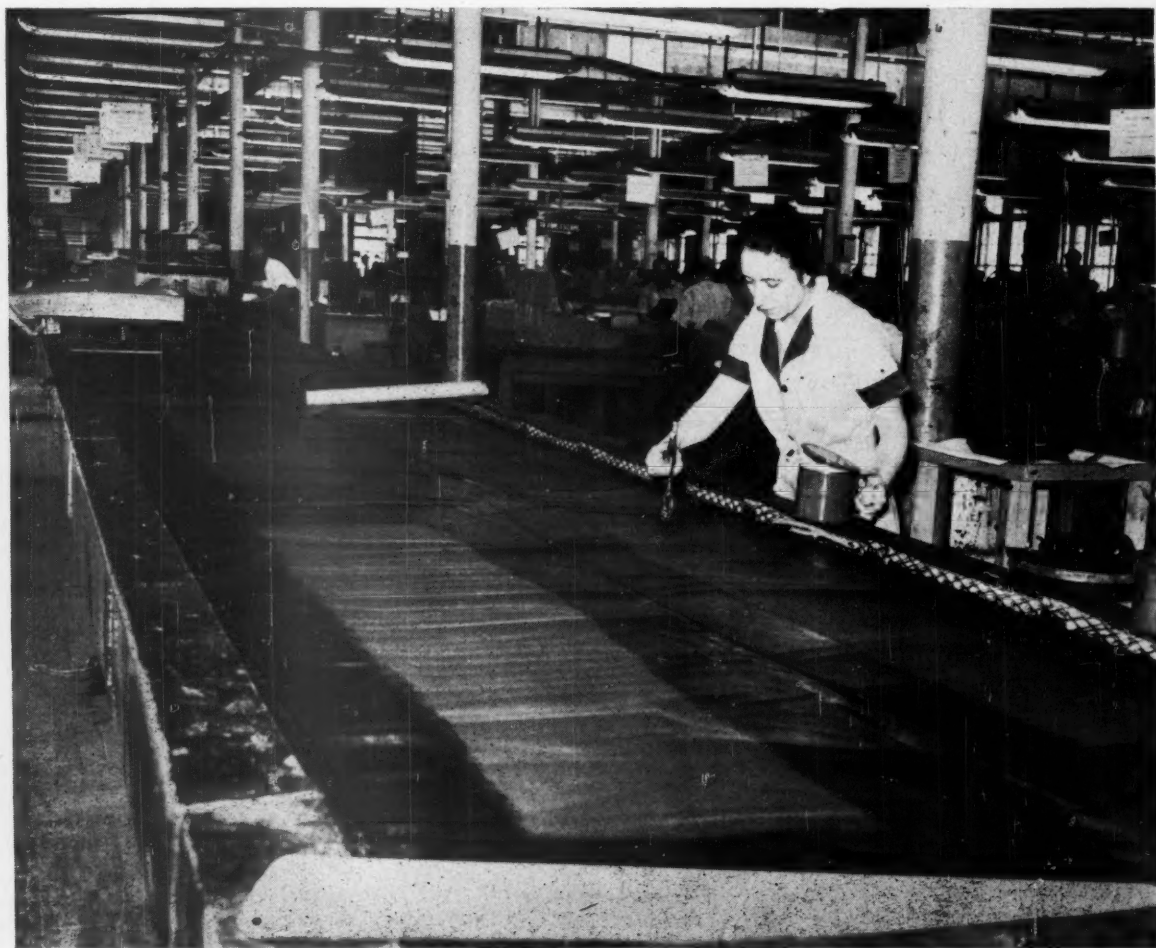

Fig. 6.
Table used for spreading cements on sheet material. Air is exhausted through grilled slot around periphery of table. Note use of self-closing cement can

flat sheets. Using this spreading table with a neoprene adhesive containing toluene as the solvent, the concentration of toluene vapor in the breathing zones of the workers was found to be 30 to 35 parts per million. With the exhaust ventilation cut off, the concentration rose to 180 to 240 parts per million. Similar operation using benzol-containing cement and no local exhaust ventilation produced concentrations up to 700 parts per million.[10]

Fig. 6 shows a table used by one of the plants of the U. S. Rubber Company for this type of work. A similar table was illustrated in a report by Thomas and Tebbins.[11] The essential differences in the table illustrated here and that described by Thomas and Tebbins is that the one illustrated in this paper employs a wider slot with lower entrance velocity and a grill covering the slot to prevent the entrance of small pieces of sheet material into the exhause system. The volume of air used was approximately 100 C.F.M. per linear foot of table perimeter.

We do not desire to discuss the subject of the design of local exhaust ventilation extensively since this subject has been amply covered elsewhere.[12] Fig. 7 shows the design of a hood which we have found adequate for the ventilation of cementing operations on large objects where moderately toxic solvents are employed. The indicated face velocity at this hood would not be sufficient to protect workers if a highly toxic solvent were being used. In such installations it is advisable to provide a turntable to support the object upon which

Fig. 7.
Local exhaust ventilation used for cementing on bulky objects

the cement is being spread so as to make it possible for the worker to remain on the upwind side of the object.

Because of the large volume of solvent being evaporated, spreading or coating operations should use local exhaust ventilation (Fig. 8) even when solvents of low toxicity are employed. Sufficient air should be exhausted to lower the concentration of solvent vapor under the hood and within the ducts to a point no higher than 25% of the lower exposive limit of the particular vapor being controlled. The openings in the hood should be so arranged that the entering velocity

Fig. 8.
Spreader showing local exhaust ventilation system. Side openings, usually kept closed, are provided for ready access to interior

will maintain the vapor in working areas at safe concentrations. Additional openings at the sides may be provided for emergency repairs, but these should be kept closed during normal operation.

Another factor which should be considered in the handling of solvents or cements containing solvents is the use of storage and work containers which present as small a surface area as possible from which evaporation may occur. The use of uncovered containers permit evaporation to occur from the entire top surface of the cement or solvent in such containers. It is not difficult to use containers which present less surface from which evaporation can occur, or to use containers which are self-closing and, therefore, do not permit evaporation to occur except when they are in actual use. Such containers include those in which the top opening is only large enough for the brush to enter, or those with a similar opening on the side of the receptacle.

Fig. 6 also illustrates the use of a self-closing cement can which was designed by E. C. Shedd, safety supervisor of the United States Rubber Company's Naugatuck, Connecticut, Footwear plant.

Brushes used for hand spreading operations should be provided with a hook so that they may be hung into a completely closed, preferably self-closing, container when not in actual use. This will help preserve the brush and also minimize the evaporation of solvent from the brush into the air.

Summary

THE decreased supply of natural rubber and the manufacture of certain war materials has necessitated the use of synthetic rubber cements produced by dissolving these rubbers in organic solvents.

Industrial intoxication from solvents used with synthetic rubbers can be avoided by substituting solvents of lower toxicity for those of greater toxicity whenever possible, the use of general ventilation with solvents of low or moderate toxicity, or the use of local exhaust ventilation with solvents of greater toxicity or whenever solvents are evaporated in such quantity that general ventilation does not suffice to control the hazard.

While maximum permissible concentrations are useful guides in the design of ventilation for the removal of solvent vapors, they are not complete substitutes for periodic medical examination of workers, especially where the more toxic solvents are employed.

[We desire to express our thanks to the United States Rubber Company for the photographs used in this paper.]

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A Modified Beaded Column
—For Absorbing Gases and Mists—

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IN THE collection and estimation of the common gases and mists encountered in plant atmosphere this Bureau has usually utilized the well known and accepted methods. From time to time, however, a need has arisen for a more convenient yet efficient apparatus for this type of work. The main requisites for such an apparatus are that it be portable, simple to operate with existing facilities in the field, utilizes small quantities of absorbing solution and in efficiency be as good as existing devices.

Such a need has been stimulated by two factors: (a) the remoteness of many plants from the central laboratory where the transport of large fragile equipment becomes difficult and discourages good sampling; and (b) a desire for facilities for taking many samples of any gas or of different gases at any time unforseen field work may demand it. Offsetting this need is the midget impinger but its efficiency for collecting gases is limited.

To expedite a study where conditions exist such as described above, a modified beaded column has been devised which is constructed out of ordinary glassware and utilizes only 5 ml of absorbing solution.

Our interest in such a type of apparatus has been centered in the absorption of HCL mist which we have had to sample much more frequently than other gases. The design of the apparatus as first used in the field is shown in Fig. 1. In a sense it combines the effi-
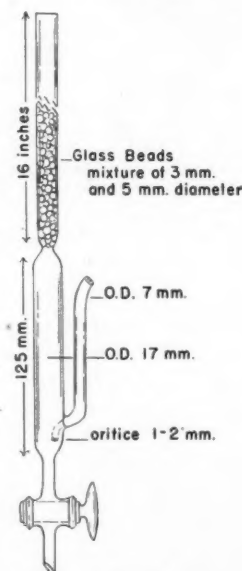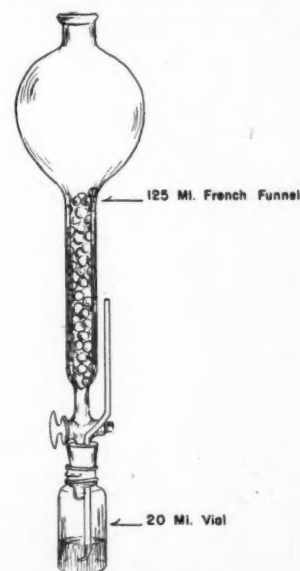

Fig. 1.   Fig. 2.

ciency of the midget impinger with that of a short beaded column. The incoming gas is subjected to an initial spray in the bulb, followed by a more thorough scrubbing as it ascends through the column. The sampling rate employed is 2 liters per minute.

Later it was observed that the column need not be as long as described and that even this apparatus

could be made simpler by substituting a 125 ml French type funnel for the beaded column and a small 20 ml vial for the bulb. The inlet tube was made from a short piece of glass tubing and mounted on the funnel by means of a two-hole rubber stopper.

In operation, the stopcock is closed and the stem of the funnel filled with absorbing solution which is then run into the vial by detaching the latter slightly from the rubber stopper. The stopcock is allowed to remain open, the vial affixed firmly, and the apparatus is ready for sampling. Using the Willson pump with a definite setting on the bleeder and a flowmeter, a rate of 2 liters per minute is easily maintained. After sampling, the column is washed down with distilled water until the bottle is full. The same precautions in washing must be observed as indicated above for allowing the liquid to run into the vial.

A few preliminary tests served to show that if the apparatus is used at a rate of flow of 2 liters per minute, only 5-6 ml of absorbing solution is ample.

TABLE I.
HYDROCHLORIC ACID

Sampling Period Minutes	M1 .01 N NaOH			HCl found in PPM		
	Column	Bubbler	Impinger	Column	Bubbler	Impinger
10	1.5	1.45	.65	18.3	17.75	16.0
15	4.6	4.3	14.5	36.8	34.8	33.5
10	5.7	5.3	7.7	71.1	66.2	69.7
5	3.05	2.8	3.55	73.7	67.5	61.0
5	3.4	3.3	4.2	85.7	83.6	77.0
5	3.95	4.1		95.1	98.5	
4	5.0	5.5		150.7	167.5	
5	9.7	9.0		234.0	230.0	
13	27.0	27.0		301.0	301.0	
5	25.5	27.3	36.0	640.0	685.0	648.0

TABLE II.
SULFUR DIOXIDE

Sampling period Minutes	M1 .0095 N Iodine		SO2 found in PPM	
	Column	Bubbler	Column	Bubbler
17	6.39	7.3	21.6	24.7
10	7.43	7.33	42.67	42.0
16	12.77	12.8	46.3	46.4
12	12.2	11.0	58.8	53.2
13	19.4	17.4	86.5	77.6
14	18.87	23.0	78.1	95.3
15	34.7	33.35	133.6	128.2

TABLE III.
AMMONIA

Sampling period Minutes	M1 .1 N NaOH		NH3 found in PPM	
	Column	Bubbler	Column	Bubbler
6	22.7	22.1	98.5	118.5
13	22.0	21.9	159.0	168.0
10	16.4	16.2	864.0	888.0
10	8.2	7.9	1191.0	1945.0
10	12.2	13.3	1400.0	1325.0

TABLES IV (A) AND (B).
CHLORINE

Sampling period Minutes	M1 .01 N AgNO3		Cl2 found in PPM	
	Column	Bubbler	Column	Bubbler
15	9.2	8.5	74.6	70.0
15	15.7	13.0	124.0	107.0
11	22.0	20.0	244.0	224.0

Sampling period Minutes	M1 .01 N Thio.		Cl2 found in PPM	
	Column	Bubbler	Column	Bubbler
10	1.5	1.5	13.0	13.0
5	10.3	9.7	178.0	168.0
8	20.6	19.7	223.0	213.0

Tables I to IV show the results obtained by simultaneous collections at 2 liters per minute using the beaded column and a fritted glass bubbler with artificially created atmospheres of various gases. The results, therefore, are on a comparative basis with those

of the bubbler. In the case of HCL a similar apparatus was mounted on a midget impinger as shown in the photograph, and a few samples taken simultaneously with the above set-up. At the increased rate of flow of the midget impinger about 1 ml more of absorbing solution had to be used. The results, however, were good in view of the versatility afforded by this means of sampling.

A brief description of the absorbing solution used and the method of analysis for the gases tried is as follows:

Hydrochloric acid:	Absorbing solution—Water Method of analysis—Titration
Sulfur dioxide:	Absorbing solution—5% NaOH Method of analysis—Iodimetric
Ammonia:	Absorbing solution—.5 N H2SO4 Method of analysis—Titration
Chlorine:	Absorbing solution— (a) 1% Na2AsO3 in 5% NaOH Method of analysis—Volhard
	Absorbing solution— (b) 5% KI Method of analysis—Titration liberated I2

The results of the tests conducted in the laboratory show that the beaded column compares very favorably with the fritted glass bubbler for the gases tried. The compactness of the assembly makes it quite portable and the small amount of absorbing solution required makes it possible to obtain a very large number of samples while in the field.

Health Hazards in Some Non-Ferrous Metal Smelters

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SINCE the beginning of the war the demand for copper, lead and zinc has markedly increased. To meet these demands the smelting industry has made many metallurgical improvements in the treatment of low grade metal deposits and has greatly increased production. Because of the importance of the products produced, the smelting industry commands an important place among the industries of this country.

It is an established fact that the health of workers is an important factor in maintaining peak production. In an

effort to meet production quotas many industries may overlook factors of health and safety with the result that production may actually decrease. While it is of great importance to produce large quantities of metals, it is also important that they be produced in the safest possible way.

The purpose of this paper is to consider briefly the health hazards associated with the smelting and refining of copper, lead and zinc, with the production of certain smelter by-products and with plants sometimes operated in conjunction with smelters. Only the treatment of sulfide type ores will be considered. Because of variations in the nature of non-ferrous metal ores and of smelting and refining processes, a complete discussion and analysis of all of the health hazards in the smelting industry would be beyond the scope of this paper.

Non-Ferrous Metal Ores

THE ores shipped to smelters vary widely and thus the smelting and refining processes also vary. The ores received usually contain small amounts of metals in addition to the primary metal and they become valuable products as the smelting and refining process proceeds. Copper ores may contain nickel, gold, silver, platinum, antimony, lead, zinc and arsenic and since all of these metals are not usually refined at any one plant, concentrates containing one or more metals are shipped to other plants for additional treatment. Small amounts of toxic metals in an ore usually become important from the standpoint of causing health hazards after the ore is concentrated and handled in the processes of roasting, smelting or refining. Quartz is the prominent gangue material in ores of copper, lead, and zinc, and silica dust is usually the chief hazard encountered in the primary treatment of ore at the smelter.

Description of Processes

IT IS NOT the purpose of this discussion to give a technical description of the smelting and refining of non-ferrous metals, but rather to discuss processes and procedures in general as possible sources of harmful dusts, fumes, mists, vapors or gases. Emphasis will be placed on the health hazards which may result from smelting and refining rather than on the metallurgy and technical features of the processes.

Briefly, the smelting and refining of ores consists of receiving ore in railroad cars from mines, dumping or unloading the cars, crushing and sampling the ores, concentrating by flotation, roasting, smelting, refining and casting. The ore smelting equipment is usually connected to a flue and stack where valuable by-products are trapped. Flue dusts may then be treated for the recovery of valuable products or be shipped to other smelters for treatment. In addition to having maintenance departments, certain smelters may operate a lime quarry to supply flux, a brick plant to supply furnace lining and a foundry to supply castings.

Ore Unloading

ORE arriving at the smelter is usually received in open swing-bottom railroad cars. Depending upon the condition of the ore, pounding of the cars or even shoveling may be necessary before all of the ore is released. Compressed air is sometimes used not only to loosen the bulk of the ore but also to clean the car thoroughly. Instead of using compressed air for cleaning, workmen may sweep the bottom of the car and undercarriage to remove any remaining ore. Ore or dust which may accumulate on the bin platform is either cleaned by sweeping or by the use of compressed air.

Ore cars may also be unloaded with equipment which inverts the car over a bin. When this procedure is used, further cleaning of the cars is not necessary unless the ore is damp or frozen and clings to the car. High grade ore and concentrates may be received in box or flat-bottom open cars and are usually unloaded by shoveling, although mechanical devices may be employed.

Crushing, Grinding and Sampling

ORE from the storage bins may dump directly to conveyor belts which transport it to crushers, screens and sample mills and finally after being reduced to the desired size, it is delivered to other storage bins. Jaw and gyratory crushers are used for primary breaking, and secondary crushers and rolls for finer crushing. In the absence of control, silica dust will originate at crushing, grinding and screening equipment and at points where ore may fall from one level to another.

Sampling mills serve as a means of diverting a representative portion of the total ore to a sample which is crushed and ground and further divided with the rejected portions rejoining the ore and the final sample riffled, bucked and ground for assaying. Sampling mills may have automatic equipment for taking and crushing the sample. In such cases, the final weight of the sample is small and preparation is accomplished by fine grinding and bucking. Other sample mills may take a large sample which is mixed and cut down by shoveling, followed by crushing, fine grinding, and riffling. After each batch of ore has been run, the mill equipment is cleaned, frequently by the use of compressed air jets.

Sample preparation rooms are often dusty since fine grinding is done in these rooms and the use of compressed air for cleaning equipment may be common practice.

Concentration

CONCENTRATION serves to separate the constituent minerals of the ore into one or more products and eliminate gangue or waste materials. Separation may be accomplished by flotation, jigs or gravity tables, or leaching. Crushed ore from the storage bins passes to roll crushers, rod or ball mills and then to the concentration process. Final grinding of the ore is usually done wet, resulting in good dust control. Wherever separation is made by flotation, concentrates are filtered and are ready for roasting.

Roasting

THE purpose of roasting is to reduce the sulfur content of the ore and to remove such volatile components as arsenic, antimony, and cadmium and to convert the bulk of the ore to oxides and sulfates. The volatile components of the ore are condensed and collected in the flue system, and in bag houses or electrical precipitating systems. The sulfur dioxide produced may be recovered for making sulfur or sulfuric acid or expelled into the atmosphere through the stack.

The roasting of copper ores may be accomplished in roasting furnaces or simultaneously with smelting. Preliminary roasting is frequently done in multiple-hearth furnaces having revolving arms which continually stir the ore. The charge is conveyed to the top of the furnace, is fed on the upper hearth and passes from the outer edge of the hearth to the center where it falls through drop-holes to the hearth below. On this hearth, the ore is raked to the outer edge where it falls through to the next hearth. The charge follows a zig-zag pattern through the furnace and finally drops into storage bins or cars beneath the furnace. It is usually necessary to clean the furnace doors, drop-holes and arms periodically which is a hand operation and may be dusty. Some leakage of fume from roasting furnaces may be observed during normal operation. Gases and volatile constituents of the ore are discharged to the flue system.

In treating lead ores, preliminary roasting may be accomplished in furnaces similar to those used for copper ores or the complete roasting may be done in sintering furnaces. In other cases, the calcine from regular roasting furnaces may be further desulfurized in sintering furnaces. A common furnace of this type is the Dwight and Lloyd sintering machine which feeds the material in an even layer on an apron or system of grates to which continuous suction is supplied. The apron moves continuously and the reaction is started at the feed end of the apron and as the burning progresses, the sulfur content of the charge is reduced. The cake is chilled before the melting temperature is reached and the cake is discharged to bins at the end of the apron. High sulfur ores may have to be run through the sintering process a second time. Draft for burning the charge is supplied by a fan connected to a suction box below the grate system and fine particles

from the sinter charge accumulate in bins below the grates which are cleaned periodically. The fumes and gases produced in this furnace are discharged to the flue system.

Roasting of zinc ores may also be done in the same type of furnace used for roasting copper ores. In such cases, the operations are conducted in essentially the same manner as in copper roasting.

After roasting furnaces have been used for an indefinite period of time, it is necessary to repair or rebuild the hearths and furnace walls. In case the furnace lining is removed, workmen break the walls and hearths with jack-hammers and throw the waste brick by hand through doors to the furnace floors. The waste brick are then loaded to wheelbarrows and dumped into cars. Through continued use of roasting furnaces, the brick lining becomes coated with arsenic trioxide which presents a hazard to the workmen doing repair or relining work.

Copper Reverberatory Furnace

THE reverberatory furnace is built of refractory brick, is fired at one end and the flues are located at the opposite end and are connected to the flue and stack system. The charge is commonly dropped from cars of various types into charging ports located at the top or sides of the furnace. Skimming doors and tapholes may be located at any point along the walls of the furnaces depending on plant layout.

The reverberatory furnace charge will vary but in addition to roaster calcine or concentrates, it may also consist of collected dust and fume, ladle skulls, refinery slag, fluxes and precipitated copper. Materials charged in the dry state, particularly calcines and flue dust and fume, may result in the loss of valuable products as well as excessive dust exposures. The reverberatory furnace matte is tapped to ladles, or to launders which empty into ladles. The matte in a molten condition gives off fume which may consist of oxides of arsenic, antimony, lead and other toxic metals. During melting of the charge, slag rises to the top and is tapped at a convenient place around the furnace. When it becomes necessary to rebuild a reverberatory furnace, the old brick structure is broken down and the brick removed. Since these brick may also be contaminated with arsenic trioxide, an arsenic hazard may result. Leakage of gas and fume from the furnace may occur at the charging ports or from breaks or openings in the furnace.

Copper Converters

THE purpose of treating copper matte in the converter is to oxidize the iron and sulfur by blowing air through the molten matte. Sulfur is liberated as is sulfur dioxide and the iron is oxidized and goes to slag and copper sulfide is oxidized to produce metallic copper.

The molten copper matte from the reverberatory furnace is dumped from ladles usually by overhead cranes into the converter. Cold ladle skulls and flux may also be added from ladles or boats. After the addition of the charge, the converter is turned to such a position that the converter opening is under a hood for collecting fumes. The charge is then blown with air until a slag forms which is removed and returned to the reverberatory furnace for copper recovery. When slag or blister copper is being removed or when the converter is otherwise in a tilted position, fumes are liberated to the building. After the formation of blister copper in the converter, the metal is poured into ladles and then to refining furnaces.

During the process of converting, considerable sulfur dioxide and small quantities of metal fumes (arsenic, antimony, zinc, etc.) may be liberated. Gases and fumes escaping the hood will be discharged to the converter building during this time.

Copper Purification and Casting

BLISTER copper from the converters is charged into refining furnaces and blown with compressed air. During this process, metal impurities are oxidized and escape as fume. The slag formed is skimmed and copper oxide formed during the process is reduced to metallic copper by thrusting wooden poles into the bath of metal. If this copper is to be further purified by electrolyzing, it is poured into anode shapes in a casting machine.

The anodes refined by the electrolytic method are lowered by means of overhead cranes into tanks containing sulfuric acid electrolyte and the copper deposited on thin copper cathode sheets. Metallic impurities collect in the bottom of the tanks as muck or slime which is given further treatment for recovery of valuable metals. After the cathode deposit has reached the proper thickness, the copper is stripped from the starting sheets and melted, fire refined and cast into desired shapes. Scrap anodes are melted in an anode furnace and recast.

Lead Blast Furnace

ROASTED or sintered ore along with suitable preparations of fuel and fluxes make up the charge for the lead blast furnace. The calcine or sintered product may be transported in larry cars to a weighing station where the charge is prepared and is later dumped into the top of the furnace from a car designed for that purpose. The reaction in the furnace produces three different products; that is, lead, slag and spiess which have different specific gravities and are easily separated. The spiess contains zinc, copper and other base metals and is further refined for zinc recovery. The slag is discarded and the lead containing small quantities of various metals is tapped from the furnace to ladles and transported to dross kettles. Loading and unloading sinter and preparing the blast furnace charge may be dusty operations. Metallic fumes may be liberated during blast furnace charging and tapping operations.

Lead Dross Kettles

LEAD from the blast furnace is dumped from ladles into large drossing kettles where it is freed of impurities. Various materials are added to the lead which is stirred by mechanical means until the impurities rise to the surface as dross. The dross contains copper, sulfur, arsenic, antimony, zinc and iron and is skimmed off by means of a large suspended perforated spoon. The dross may be treated in a reverberatory furnace for separation of lead from the copper and other metals. The lead is returned to the drossing kettles and the copper matte is sent to a copper smelter for further treatment. After drossing, the lead bullion is treated with metallic zinc which collects the gold and silver in a zinc dross. The desilverized bullion is then further refined for the removal of zinc.

The refined lead is pumped or siphoned to a casting machine. The lead pigs are taken from the casting machines and stacked in railroad cars for shipment.

Zinc Leaching and Electrolyzing

WHILE there are a number of metallurgical processes used for the recovery of zinc, only the electrolytic process and the operations associated with it will be considered in this discussion.

Zinc calcine from the roasting furnaces contains zinc oxide and sulfate which are soluble in sulfuric acid. Lead and certain other metals are insoluble and comprise a residue in a sulfuric acid treatment. The handling of calcine in the dry state, and particularly loading, unloading, and screening, may prove to be dusty.

In practice, the zinc calcine may be taken from the roasters or storage bins and conveyed, or transported in open cars to the leaching plant. The calcine may then be screened and the oversize crushed and returned for further roasting. The screened calcine is then fed to sulfuric acid leaching tanks where the zinc is dissolved. The resulting neutral solution is thickened and finally filtered to remove the residue. The residue contains lead and may be dried in rotary drying kilns and loaded to railroad cars. This residue may be treated further or shipped to a lead smelter. The drying and loading of zinc residue may prove to be dusty in the absence of adequate control.

When the zinc is dissolved in sulfuric acid, certain other metals present in the calcine are also taken into the solution. These impurities are precipitated by agitation of the solution with zinc dust. Should the zinc solution be slightly acid during this treatment, it is possible that arsine gas

will be produced through the combination of hydrogen and arsenic which may be present. The solution from the purifying tanks is filtered and the filter cake treated for recovery of valuable products or shipped to other plants for treatment.

After purification is complete, the zinc sulfate solution is delivered to electrolytic cells for precipitation of zinc. The cell anodes are lead and the cathodes aluminum. After the desired thickness of zinc has accumulated on the cathodes, they are lifted from the cells by means of chain blocks and the zinc deposit stripped from the aluminum cathode by means of a heavy knife. The zinc sheets are piled on small cars and transferred to melting furnaces.

During the electrolyzing of zinc, gas is evolved from the cells which forms a sulfuric acid mist or spray. This acid mist is very irritating to the nose, throat and upper respiratory passages of workmen.

Melting and Casting

THE cathode sheets from the electrolytic cells are placed in a reverberatory smelting furnace. During the melting period, a dross forms on the surface of the metal which is skimmed into small cars or wheelbarrows and transported to revolving drums where molten zinc is removed from the dross. Casting of the metallic zinc is done from ladles into iron molds. The cooled zinc slabs are piled in railroad cars for shipping.

Zinc dust for use in purifying zinc sulfate solution may be made in the casting department. This is done by blowing compressed air through a stream of molten zinc and the dust is collected in a chamber.

By-Products

CADMIUM. The principal sources of cadmium as a by-product of smelters is from cadmium-bearing lead blast furnace fume, and from residue from the purification of zinc sulfate solution preliminary to the electrodeposition of zinc. In the recovery of cadmium, the products are first treated with strong sulfuric acid followed by neutralization with hydrated lime and filtration. The filtrate is then delivered to electrolytic cells and the cadmium deposited on aluminum cathodes. The cadmium sheets are melted and poured into various marketable forms.

ARSENIC. The flue dusts from various roasting and smelting processes are usually rich in arsenic and are collected from the flue system, electric precipitator units and bag houses. The production of white arsenic is often carried out in two stages; namely, the production of crude arsenic followed by refining of the crude. Flue dust collected at precipitator units or bag houses is removed, after an appreciable quantity has accumulated, and transported to arsenic roasters. Dust from the flue proper is also delivered to the roaster although frequent flue cleaning is not always necessary.

Flue dust removed at the precipitator falls into hoppers where it is drawn off into open cars which may vary in size. Compressed air may be used to aid the flow of dust from the hoppers. The tops of the cars may be sprayed with water, to reduce loss of dust during transportation. At these loading stations, considerable flue dust may accumulate on the floor necessitating periodic cleanup. Bag house dusts may also be collected in hoppers or on the floor under the bags. In the latter case, dust removal may be accomplished by shoveling into wheelbarrows and dumping to open cars. Either method of loading may prove to be dusty in the absence of engineering control.

The flue dust is dumped from the cars to hoppers and fed into roasting furnaces. The arsenic is volatilized in these furnaces and passes through condensing chambers and finally accumulates in hoppers below the chambers. Residue from these furnaces is returned to one of the roasting or smelting processes and the waste gases and fumes are discharged to the flue system. In some plants, crude arsenic suitable for certain commercial uses is shipped without further treatment.

The crude arsenic is withdrawn from the hoppers into open or closed cars and transported to the arsenic refinery. The cars are dumped into hoppers and the crude arsenic fed into refining furnaces. The volatilized arsenic passes through a series of large brick rooms or kitchens where it condenses and the waste gases and any remaining fumes enter the flue system. The arsenic condensing in the first kitchen usually contains impurities and is returned to the arsenic roasters. After sufficient white arsenic has accumulated, the kitchens are opened and the arsenic loaded into wheelbarrows and dumped into a hopper. It is drawn from the hopper, ground and screened, and either packed in barrels or bulk loaded into railroad cars.

SULFURIC ACID. While sulfuric acid is not truly a by-product of smelters, it is sometimes produced from sulfur dioxide which is a by-product of roasting, sintering and smelting operations. Likewise, iron sulfide may be recovered from certain ores and used as a source of sulfur dioxide. The sulfuric acid may be produced either by the contact or chamber methods.

Miscellaneous Operations

FOUNDRY. To meet the need for replacement parts for equipment and iron balls for grinding mills, smelters sometimes maintain a foundry. While iron balls may be poured in permanent molds, most of the castings must be poured in sand molds. In such cases, the methods used will not vary materially from the usual iron or brass foundry practice. The foundry operations will consist of pattern and core making, sand conditioning, molding, pouring, shakeout and casting cleaning. Where only rough castings are made, sand blasting as a cleaning method may not be used.

BRICK MANUFACTURE. Smelters use large quantities of brick of various sizes and shapes for roaster, blast and reverberatory furnace and copper converter linings; for this reason, certain smelters may maintain a brick plant. The operations involved in such a plant will involve quarrying, crushing, grinding, and mixing the rock, brick molding, drying, setting the brick in a kiln, burning or firing the brick and unloading the kiln.

ORE SAMPLE PREPARATION. The sampling of ore was mentioned above but the procedure followed in preparing these samples for assay was not discussed. After a representative ore sample has been collected, it is passed through a preliminary grinder, bucked and then ground to pass a fine screen. Samples are packaged in small envelopes and sent to the assay laboratory. The grinding mills are cleaned after each sample and compressed air is frequently used for this purpose. Samples of concentrates and other materials are handled in a similar fashion although wet materials are dried prior to grinding. Sample preparation rooms are given particular mention here since these rooms can become very dusty unless attention is given to preventive measures.

MAINTENANCE. Workers in maintenance departments may be required to work in one or all of the operating departments of a smelter over a period of time. The work of some may be mostly outside, while others may be required to enter places not ordinarily visited by regular department employees. Repairs may be needed in confined places or even inside of equipment. For this reason, this group of workers may be exposed to a large variety of toxic materials. Since the length and severity of their exposures will vary, the health hazards of maintenance workers should not be disregarded.

CHEMICAL LABORATORY. Smelters maintain chemical laboratories which perform a large number and variety of assays. The use of large quantities of chemicals in such laboratories necessitates well ventilated work rooms.

Health Hazards

DUSTS. The most important factors in the development of silicosis through exposure to dusts are composition (quartz content of the dust), size distribution of the dust particles and concentration of the dust in the workroom atmosphere. Since quartz is the most common gangue material associated with non-ferrous metal ores, dust hazards may arise during unloading, crushing, grinding, screening, sampling or in otherwise handling the ores prior to flotation. The use of compressed air in unloading and in cleaning grinding equipment increases the dust hazard as will the falling of fine dry ore from one level

to another in the crushing and conveying system. Dust hazards may occur in ore sample preparation rooms through handling and grinding of samples and cleaning grinding equipment. When equipment cleaning is done with compressed air, more dust will be produced.

Dust hazards may also occur in connection with roasting and smelting operations, and calcine loading, unloading and screening. However, flotation removes most of the silica from the ore with the result that the dust hazard is of less importance than other hazards. At the roasting stage of the process, the dusts may contain toxic metals and constitute a different type of hazard.

Foundries and brick plants operated in conjunction with smelters present possible dust hazards. The principal dust-producing operations in foundries are molding, shake-out, casting cleaning and sand conditioning. Shake-out and casting cleaning may be particularly dusty unless precautions are taken. In brick plants, fine grinding and screening of dry ore will be particularly dusty and these operations will contaminate other operations which may be located nearby. Ore crushing, kiln loading and unloading may also be dusty.

LEAD. The inhalation of lead dust or fume by workers may result in lead poisoning and for this reason lead hazards associated with many smelting processes are important.

While exposures to lead will result from crushing and grinding of lead ores, whether or not these operations will cause lead hazards will depend on the lead content and nature of the ores. However, if the dust hazards associated with these operations are controlled by engineering methods, the lead hazard will also be controlled.

The possibility of harmful exposures to lead in roasting, smelting and refining of lead ore is ever present, since whenever lead ores are heated or handled fume or dust may contaminate the workroom atmosphere. Sintering and lead refining will usually present greater lead hazards than smelting. Handling and transporting lead calcine or sinter in the dry state frequently results in lead hazards as does the preparation of the blast furnace charge.

Cleaning of the flue system, including bag houses and electric precipitators, will result in high exposures to lead and to certain other toxic metals present in the flue dust. Bucking, parting and sample preparation rooms are frequently contaminated with lead dust when materials being handled contain lead. The use of compressed air for cleaning equipment will add to workroom contamination.

Lead is usually found associated with zinc ores and frequently with copper ores. This being true, lead hazards may occur at copper and zinc roasting, and copper smelting and refining operations. The handling and treatment of zinc calcines frequently result in lead hazards, and particularly the drying and loading of residue from zinc leaching operations. Lead hazards in cadmium refining plants, and in acid plants where lead burning is done may also occur.

Such miscellaneous operations as lead casting and burning may result in lead hazards, particularly if this work is done in confined places. In bronze foundries, lead hazards may result from melting, pouring and even from shake-out and molding. Sources of lead dust during the latter operations are from the molding sand which will normally become contaminated with lead through continued use with bronze.

ZINC. Compared with lead, arsenic, and certain other metals, zinc has a low order of toxicity. The principal hazard in exposure to zinc is the breathing of freshly formed zinc oxide fume. Such exposure may occur in the refining, melting and pouring of zinc metal and the handling and refining of lead blast furnace spiess. While other zinc exposures may occur in a smelter, there are usually other materials present which have a higher order of toxicity and therefore constitute the chief hazard. In such cases, control of the more hazardous material will result in control of the zinc hazard.

ARSENIC. Arsenic may be found in the atmosphere of many departments of a smelter although more serious hazards will occur in cleaning flues, bag houses and electric precipitators, loading and unloading flue dust, roast-ing and refining arsenic and roasting of ores. The dropping of dry flue dust from hoppers or the cleaning of bag house floors will normally be very dusty, as will clean-up around loading stations, and the initial stages of spraying dust cars with water. In the roasting of ores containing arsenic, fume may be discharged to the workroom atmosphere; however, the extent of the hazard will depend on the type and operating condition of the roasting furnaces, operating procedures and the suction head applied to the furnaces through the flue. Operations connected with arsenic roasting and refining, such as loading and unloading flue dust or crude arsenic, cleaning of arsenic kitchens and the handling of refined arsenic may result in serious exposures to arsenic. Other but perhaps less serious arsenic hazards may occur at copper reverberatory and converter blast furnaces, lead and lead dross kettles. Where materials containing arsenic are handled in sample preparation rooms, arsenic exposures may occur. In some cases, the atmospheres of even non-arsenic using departments may be contaminated to some extent with arsenic because of their close proximity to departments handling flue dust or other arsenic-containing materials.

Repairmen required to enter roasting or reverberatory furnaces to repair or remove furnace linings may be exposed to high arsenic concentrations.

The extent of the arsenic hazard in the various departments of a smelter will depend to a large extent on the arsenic content of the ores and the processes and handling methods used. The possibility of skin irritation is always present where arsenic is encountered.

ANTIMONY. While antimony may be present in non-ferrous metal ores, the quantity is usually small. The principal exposures to antimony will undoubtedly occur in the handling of flue, bag house and electric precipitator dusts. However, in such cases, exposures to other toxic metals will occur and perhaps constitute more serious hazards. During the refining of lead in dross kettles and of copper in converters, antimony may be liberated and contaminate the workroom atmosphere. In roasting operations there are also possibilities of workroom contamination. The extent of antimony hazards in a smelter will depend on the quantity of antimony present in the ores and the smelting and refining procedures used.

CADMIUM. Non-ferrous ores would not ordinarily contain sufficient cadmium to result in serious exposures to the metal during ore dressing processes, although the metal may present a hazard in sample preparation rooms. As was true in the case of antimony, greater cadmium hazards will probably occur in the handling of flue and bag house dusts than in any other department with the possible exception of the cadmium refinery. During the recovery of cadmium from flue dusts and from the residue resulting from the purification of zinc sulfate solution, either cadmium dust or fume exposure may result. During the melting of cadmium metal, extreme care must be taken to prevent exposure to cadmium oxide fume.

SULFUR DIOXIDE. Large volumes of sulfur dioxide gas will be given off during the roasting of sulfide ores and sufficient quantities may be liberated to the room atmosphere to cause a hazard. Likewise, high concentrations may also occur in the vicinity of reverberatory and converter furnaces. Where overhead cranes are used for handling copper matte and refined copper, the operators may be exposed excessively. These workmen may also be exposed to the various metals which may be liberated during the copper converting process. There are other departments in a smelter where sulfur dioxide gas may occur; however, in these departments concentrations are less likely to be dangerous.

SULFURIC ACID MISTS. Serious sulfuric acid mist hazards may occur in zinc electrolyzing rooms. Sulfuric acid mists in such tank rooms are caused by the liberation of gas bubbles from the cells which carry small droplets of sulfuric acid and in the absence of adequate control, these mists are liberated to the workroom and are breathed by the workmen. This hazard is not only important from the standpoint of breathing the mists but also of skin irritation.

CARBON MONOXIDE. Since the process of combustion may

be a source of carbon monoxide, this gas may be found at smelting operations. However, in actual practice, harmful concentrations of carbon monoxide will not ordinarily result unless incomplete combustion occurs in the various furnaces and the resulting gases are liberated to the workroom.

The use of salamanders or open gas heated burners is a common practice for heating workrooms in smelters during winter months. Provided these devices are not properly vented, carbon monoxide concentrations may occur, particularly where the heating unit is in a confined space.

OTHER HEALTH HAZARDS. Workers in sulfuric acid plants may receive sulfuric acid burns in addition to the possibility of exposure to sulfur dioxide, sulfur trioxide and oxides of nitrogen. However, exposure to the above mentioned gases will usually result only when the process is not operating properly or when leaks occur in the system. Selenium and tellurium may be present in flue dusts and may contribute to toxic metal hazards encountered in the handling and treatment of these dusts. The purification of zinc sulfate leach solution may result in an arsine gas hazard should the solution be acid. Since the zinc sulfate solution is normally neutral at this stage of treatment, the hazard may not occur or be intermittent depending upon the efficiency of the operation.

Atmospheric temperatures in the vicinity of roasters, reverberatory plants and converter furnaces are usually high. During cold weather, workmen may experience sudden changes in temperature due to drafts or to moving about a plant or department in the performance of regular duties. These changes in temperature may be contributing causes of respiratory diseases and general illness.

There may be other health hazards associated with the smelting of copper, lead and zinc, depending on the nature of ores being treated and the processes used. In many smelting processes, exposure to more than one toxic material is common and frequently the necessity of installing engineering control measures may be based on any one or all of the hazards.

Preventive Measures

THE prevention of health hazards in industry is chiefly an engineering problem. Because of variations in smelting processes and the large number of potentially harmful materials encountered in this industry, the control of dusts, fumes, mists and gases is a complex problem. A method of control used successfully in one smelter may not be applicable to another and for this reason each hazard may have to be considered as an individual problem. There are, however, certain general methods of control which may be applied for the elimination of occupational disease hazards. These methods are: (1) Wet methods. (2) Local exhaust ventilation. (3) Isolation of hazardous processes. (4) General ventilation. (5) Personal protection (respirators, protective clothing and protective ointments).

In order for a control method to be completely successful, it should not interfere with the process or with the worker in the performance of his duties. However, in some instances, education of workers to adopt new procedures is necessary to ensure effective control. The application of control to certain processes may necessitate relocation of equipment and changes in general operating procedures.

The prevention of illness among workers due to dust, fume, mist, vapor and gas hazards requires a scientific approach. An understanding of the processes involved and of the principles of ventilation and hood and exhaust system design are necessary.

The first step in the control of a health hazard should be the determination of the nature and extent of the hazard. Once the hazard has been evaluated, it is then necessary to choose the most applicable control method or methods and design and install the control equipment. Proper design of control equipment is essential in order to accomplish the result desired at a minimum cost of installation, operation and maintenance. Adequate maintenance of the equipment and periodic checks of its efficiency through studies of the workroom environment are important.

Good housekeeping is an important aid in reducing health hazards in smelters. Frequent cleaning of equipment and places of dust accumulation and maintaining an orderly plant not only serves to eliminate sources of atmospheric contamination but also has a favorable psychological effect upon workmen.

Wet methods are the cheapest and the most effective methods of controlling dust. These methods are used extensively in many industries but are limited in their application in certain plants since the addition of water may interfere with an operation or process. The entrapment of dusts, fumes, vapors, mists and gases at their point of origin by local exhaust ventilation systems is an effective control method. This method has had wide application in industry in general. The hoods used in this type of control may be of various sizes and shapes and are designed so that the air-borne materials will fall or be projected into the hood in the direction of airflow.

Isolation as a control method involves the principal of concentrating the harmful material sources to one locality or to a single closed space. In this way, hazards are confined to a small area and a minimum number of workers are exposed. Provided when workers are required to enter these areas, they are given complete respiratory protection. An example of isolation of a dusty process is the foundry abrasive cleaning room. These rooms are ventilated and the blaster or operator is equipped with a respiratory protective device.

Where the hazard at an operation or process cannot be controlled by one or a combination of methods described above, it is necessary, to furnish the worker with personal protective devices. If the hazard is a dust, mist, or fume, filter type respiratory protection may be used. Positive pressure masks or helmets may be used for protection against other toxic materials. Personal protection against skin irritants includes the use of ointments, protective clothing, rubber gloves and boots. When personal protection methods are used, close supervision is frequently necessary to attain the desired results.

For further protection of the health of workers, healthful drinking water and sanitary drinking fountains, clean lockers, showers and change houses should be provided. Salt tablets should be provided for workers employed in hot atmospheres to replace the salt lost in sweat.

Summary

CERTAIN processes involved in the preparation, smelting and refining of copper, lead and zinc ores and the treatment processes for certain by-products of these metals have been outlined. Health hazards associated with these processes are discussed as are operations and hazards in plants sometimes operated in conjunction with smelters together with general measures for controlling these health hazards.

The processing of copper, lead and zinc ores and their smelting and refining present many potential health hazards as does the treatment of the by-products of these metals. The most common and important of these are silica dusts, arsenic and lead dusts and fumes, and sulfuric acid mists. Other hazards are zinc, cadmium, antimony, selenium and tellurium dusts and fumes and sulfur dioxide, arsine, nitrogen oxides and carbon monoxide gases. Skin irritation hazards among workers with arsenic dust and acid solutions are common. Many smelter workers are exposed to extremes of temperature which may be a contributing cause of illness.

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Industrial Hygiene Panel
—Included in the Third Chicago War Production Conference—

AMONG the Panel Sessions of the Third Chicago War Production Conference held at the Stevens Hotel, Chicago, March 29, 1945, under the sponsorship of the members of the Chicago Technical Societies Council, was that on "Industrial Hygiene Services" presented by the Chicago Section, AMERICAN INDUSTRIAL HYGIENE ASSOCIATION. The purpose of the program as given below, was to acquaint the attending representatives of industry in the Greater Chicago area with the various sources of services available as indicated by the subjects:

CHAIRMAN: WARREN A. COOK, Director of Industrial Hygiene and Engineering Research, Zurich Insurance Companies.
"Federal Government Agencies" — MAJOR ALLEN D. BRANDT, Safety & Security Division, Office of the Chief of Ordnance.
State Divisions of Industrial Hygiene:
"Labor Department"—JAMES CROSSER, JR., Chief Engineer.
"Department of Public Health"—KENNETH MORSE, Supervising Engineer.
"Private Consultants and Universities"— C. O. SAPPINGTON, M.D., DR.P.H., Industrial Hygiene Consultant, and Editor INDUSTRIAL MEDICINE.
"Insurance Companies"—WARREN A. COOK, Zurich Insurance Companies.
"Industry"—JOHN B. LITTLEFIELD, Industrial Hygienist, American Brake Shoe Company.

The number and scope of the Federal Agencies in industrial hygiene are seldom appreciated even by those closely associated with the subject. MAJOR BRANDT, assigned by the U. S. Public Health Service to the Ordnance Department under the immediate direction of LT. COLONEL WILLIAM J. McCONNELL, presented the following describing these services:

On the Federal Level

ALLEN D. BRANDT: The bulk of the hygiene work of the Federal government is done by five agencies which are, in alphabetical order: Army, Interior Department, Labor Department, Navy, and Public Health Service.

ARMY: The over-all supervision of the Army industrial hygiene program centers in the Occupational Health Division, Preventive Medicine Service, Office of The Surgeon General of the Army. The War Department assumes a certain amount of responsibility for the working conditions and medical services for the employees in the War Department establishments and even in those private plants which have contracts with the War Department of such nature that failure in production might hinder the successful prosecution of the war. The War Department, through the Army Industrial Hygiene Laboratory, the Armored Forces Medical Research Laboratory, the Public Health Service, and the trained industrial hygiene personnel of all categories assigned to the Service Commands, the Army Air Forces, Chemical Warfare Service, Ordnance Department, Transportation Corps, and other headquarters, and to many of the installations and depots, provides complete industrial hygiene services to its employees and to many other workers engaged in the manufacture of materiel and equipment essential to the war effort. These services include (1) research into the toxicity of new materials of interest to the War Department, (2) chemical and engineering field studies to evaluate potential health hazards and to determine the effectiveness of control measures, (3) engineering design of control measures for existing health hazards, particularly ventilating systems, (4) laboratory analysis of atmospheric samples of air contaminants and of bulk samples of potentially harmful substances, and (5) medical surveys and consultations to evaluate and improve the effectiveness of the medical program in the different establishments. Prior to the present war, the Army had no industrial hygiene program. However, the program in effect today is a good one as is evidenced, for example, by the extremely low incidence of occupational diseases in a very hazardous industry — the explosives manufacturing, loading, and storing industry. You will remember that prior to the beginning of the present national emergency the amount of TNT, tetryl, ammonium picrate, lead azide, mercury fulminate and other military explosives manufactured in this country was essentially nil, and almost no shells were being loaded. The plants now doing this work grew from cornfields overnight with not even a nucleus of trained personnel to draw upon. Nevertheless, a good industrial hygiene program was undertaken almost from the start of plant operations, and it has paid real dividends.

INTERIOR DEPARTMENT: The industrial hygiene activities of the Department of the Interior are conducted largely by the Bureau of Mines. These activities consist of (1) development of equipment and procedures for measuring atmospheric contaminants; (2) laboratory studies, surveys, and inspections to evaluate unhygienic conditions and to appraise sanitary and medical facilities in mineral industries; (3) application of control and corrective procedures to improve the working environment; and (4) official testing and approval of respiratory protective devices. Some of the recent developments for measuring atmospheric contaminants are the filter paper sampler for dusts, an improved microprojector for dust counting, the phosphomolybdate method for determining carbon monoxide, and the phenol disulfonic acid method for determining nitrogen oxides. Laboratory studies have been conducted on the composition of Diesel exhaust gases with the viewpoint of evaluating the hazards that might be encountered from the toxic gases from the use of Diesel locomotives in mines and tunnels. Laboratory studies have been conducted on the toxic gases produced by decomposition of electric cable insulation and plastics. Surveys and inspections have been made in coal and metal mines, tunnels, and smelters to evaluate hazards from exposure to pneumoconiosis-producing dusts; heavy metals such as lead, manganese, cadmium, and zinc; gases such as carbon monoxide, aldehydes, and oxides of nitrogen; and to appraise sanitary and medical facilities. In regard to the control of unhygienic conditions, main emphasis has been placed on control of dust in coal mines, with less emphasis on conditions in metal mines, tunnels, and smelters. In coal mines considerable progress has been made in a wider application of water to reduce air dustiness during the cutting of coal, during loading and hauling, and at the tipple. These procedures, together with improved ventilation, have been quite fruitful in improving dust conditions in anthracite and bituminous coal mines. Another control procedure, the use of respiratory protective devices, has continued to receive attention. The Bureau of Mines now approves all types of respiratory protective devices and Bureau approved devices are widely used. Also, information has been made available on the dilution of stack effluents. In addition to the work in the laboratory and in the field, another important phase of the work is the dissemination of information which is accomplished by technical publications, letters, and exhibits, and by visits to the laboratory.

LABOR DEPARTMENT: The industrial hygiene activities of the U. S. Department of Labor are conducted by the Division of Labor Standards. This agency carries on a promotional and service program in the field of industrial health and safety. In this connection, the Division advises management and workers concerning methods for the control of industrial atmospheric contaminants, and excessive heat and humidity, which may be toxic or otherwise injurious to the health and efficiency of workers. In cooperation with recognized authorities in the field of ventilating engineering and by means of surveys by consultants as well as by correspondence, the Division serves as a clearing house of information in these fields throughout the United States, and in addition exchanges pertinent material with other countries. The experience of industries here and abroad is pooled and serves to assist in the solution of many technical difficulties which arise in the control of health hazards. In the synthetic rubber industry, for example, this agency took part in the standardization of control measures

for many of the solvents in use, not only from the standpoint of working efficiency but also for the reduction of fire and explosion hazards. The Division's engineers assist the state labor departments in the formulation of protective codes and regulations.

NAVY: The Industrial Hygiene Division of the Bureau of Medicine and Surgery maintains complete facilities at 15 shore establishments for consultation on industrial hygiene problems in Navy yards and stations. At these activities, there are specially trained medical and technical officers and completely equipped laboratories with scientific apparatus for evaluation of any exposure which might endanger the health of workers. Many other naval activities have officers trained in industrial hygiene with facilities and apparatus for making such tests as dust counts, vapor concentrations, and oxygen deficiency. At those stations where personnel and equipment are not available, these services are furnished from other stations upon request to the District Commandant. In addition to the more or less routine field studies pertaining to the evaluation and control of health hazards, these industrial hygiene units carry out research and development on new sampling devices, methods, and techniques, and on better and simpler methods of control. For the sake of convenience and because of similarity the industrial hygiene program operating in the Maritime Commission is included in this same group. Strictly speaking, it is not part of the naval program but covers all yards not owned by the Navy of which there is a large number. In the conduct of its program the Maritime Commission receives assistance from the Public Health Service, Navy, and State Industrial Hygiene Divisions. The Maritime Commission with the help of personnel from the Public Health Service and the Navy completed recently a special study of welding fumes and their effects upon welders in a representative number of large yards. Among other things, this study included almost 5000 chest x-rays of welders and thousands of samples of welding fumes and gases. The results when compiled will probably go a long way toward establishing conclusively any relationship which may exist between "welder's lung" and occupation.

PUBLIC HEALTH SERVICE: Last, but by no means least, is the Public Health Service. The industrial hygiene program in this agency is carried out by two divisions, the Industrial Hygiene Division and the Industrial Hygiene Research Laboratory. The Industrial Hygiene Division conducts the field operations and has for its objective the health conservation of manpower by protecting and improving the health of the worker. The method of operation is, very briefly, as follows: (1) Personnel and equipment are lent, and other forms of assistance are given to the 47 industrial hygiene units in 38 states. In this connection,

66 trained workers were lent to 28 states, the Tennessee Valley Authority, the Army, and the National Society for the Prevention of Blindness. The personnel are engaged in a variety of activities aimed at the improvement of working conditions and the reduction of sickness absenteeism in many and varied industries and plants. (2) Industrial dentistry and industrial nursing programs are being promoted in industry and in the State and City Industrial Hygiene Units. (3) Seminars are held from time to time to bring all field personnel, Federal, state, city, and industrial up to date on newer procedures and methods. (4) The field work of the industrial hygiene program in all Army-Owned Contractor-Operated Ordnance plants manufacturing or handling explosives is done by personnel from this Division. (5) Personnel and equipment were lent to the Maritime Commission to assist in the shipyard welding study mentioned previously. (6) Other cooperative studies are conducted with such agencies as the Navy, the Rubber Reserve Company, the Naval Medical Research Institute, the War Production Board, the U. S. Department of Labor, the Industrial Hygiene Foundation, and the Army Industrial Hygiene Laboratory on problems vital to the war effort. The Industrial Hygiene Research Laboratory of the National Institute of Health has devoted at least 90% of its efforts and resources during the war years to research and laboratory services requested by the Bureau of Ships, Bureau of Medicine and Surgery, and the Bureau of Aeronautics of the U. S. Navy; the Quartermaster Corps, Ordnance Department, and Office of The Surgeon General of the U. S. Army; and the Medical Division of the U. S. Coast Guard. The remaining 10% of the research has been concerned with determination of the potentially harmful effects of new chemicals prior to their widespread use. All these activities during the fiscal year 1944, for example, resulted in 70 written major confidential reports, and 13 major investigations for other governmental agencies. This work included (1) investigations into the toxicity and potential danger of such substances as new blending ingredients for aviation gasoline, DDT, new explosives, a variety of solvents, and new and strategic metals; (2) testing protective clothing of all kinds for the Armed Forces; (3) studies in sanitary ventilation, that is, the destruction of air-borne bacteria by ultra-violet light; (4) testing and developing breathing equipment for high altitude flying; (5) development of new analytical methods for determining minute amounts of substances; and (6) numerous other special investigations and services all of which pertained directly to the war effort.

State Labor Department

MR. CROSSER outlined the Health and Safety Act of the State of Illinois which gives the State Labor

Department authority to issue and enforce orders under the regulations drawn up by the Illinois Industrial Commission. The Labor Department maintains a laboratory and field staff for the investigation of industrial conditions affecting health of the worker. Plans for ventilation systems are submitted to the Labor Department for approval. Requests for services are received from workers, industry, labor unions—in fact, from any one who may have a complaint or may wish to have a condition investigated. Much work devolves upon the Labor Department Industrial Hygiene Division where the reason for leaving a job and applying for unemployment insurance is ascribed to unhealthful working conditions.

State Department of Public Health

MR. MORSE referred to the development of the Department of Public Health Industrial Hygiene Division under the guidance of the U. S. Public Health Service. Proceeding on the basis of service and education, this Division approaches the subject of industrial hygiene as a portion of the whole public health problem. It is recognized that, in addition to the occupational diseases as such which are covered by the Workmen's Compensation Laws, many diseases which are classed as non-occupational have higher rates among occupational groups. Therefore industrial hygiene must be far-reaching if both industry and labor are to benefit. This implies more than engineering activity by itself—attack by the coordinated public health team of medical, dental, nursing, engineering, and chemical professions is also essential. With such a fundamental concept of industrial hygiene problems, surveys are made of occupational disease problems, on the completion of which, detailed reports are submitted in which recommendations are substantiated by factual, impartial findings. MR. MORSE concluded that the Division with which he is associated is an impartial scientific agency of the State Department of Public Health constituted to service industry, labor, the medical profession, and others interested.

Private Consultants and Universities

DR. SAPPINGTON first outlined the universities which are undertaking industrial hygiene services, listing them chronologically. In 1918 the Harvard School of Public Health, Harvard University, presented the first courses on instruction and research in industrial hygiene which lead to degrees of graduate school levels. Since that time Harvard School of Public Health has been most active among the universities in undertaking instruction and research in this subject. PROFESSOR PHILIP DRINKER has been lent for the present to the U. S. Maritime Commission to serve as Chief Industrial Hygiene Consultant to them. In 1922 the Saranac Laboratories introduced in their program pathological experiments on lung tis-

sue of animals exposed to dust. Since then the laboratory facilities have extended to field services which have instituted and supervised industrial hygiene programs for various important industries. The Saranac Laboratories are available for private consultation in research relative to dust conditions and, headed by DR. LEROY U. GARDNER, are the foremost authorities in this field in this country and in the world. With the introduction of the lead tetraethyl problem in 1925, the Kettering Laboratory of Applied Physiology at the University of Cincinnati was set up under the direction of DR. ROBERT A. KEHOE for developing a program to avoid poisoning by this substance in either the manufacturing or blending operations and also in the distribution of gasoline to which lead tetraethyl has been added. Since 1925, the Kettering Laboratories have become interested in many other problems and are available for consultation on a research level. Among the subjects on which they have made outstanding contributions are hydrogen fluoride and other fluorides and the nitroparaffins. In 1935 the Industrial Hygiene Foundation was formulated at Pittsburgh. This group, made up of members including many of the large industrial concerns confronted with occupational disease and industrial hygiene problems, maintained consultation service for the member companies. This Foundation has placed an able staff in the field for this purpose, and has an industrial hygiene laboratory at Mellon Institute to establish a separate department of industrial hygiene was the University of Pittsburgh Medical School which has been engaged in research and private consultation since 1936. At about this time the University of Illinois Medical School, cooperating with the Division of Industrial Hygiene of the State Department of Health, established an industrial clinic which is available to the industry and labor in this area. In 1941 the late DONALD E. CUMMINGS established a Division of Industrial Hygiene at the University of Colorado Medical School and hospital. This is now fully equipped and is undertaking consultation work throughout the Rocky Mountain areas. The School of Public Health at Johns Hopkins University in Baltimore has been collaborating with the Army in the establishment of their industrial hygiene laboratory which was organized in 1943. In 1945 the Pacific Industrial Hygiene and Research Foundation was founded at Los Angeles for the purpose of offering consultation and undertaking industrial hygiene work on a consultation basis. Other universities where industrial hygiene has been conducted are Ohio State University under the direction of DR. EMERY R. HAYHURST; University of Pennsylvania under the direction of HENRY FIELD SMYTH and Columbia University under the direction of DR. FREDERICK FLYNN. Among the private consultants may be mentioned DR.

CAREY P. McCORD who serves as consultant for the Chrysler Corporation but is available for, and undertakes, much private consultation. DR. HAYHURST and DR. SMYTH have now discontinued their direct contact with the Universities and are active in consultation. DR. C. O. SAPPINGTON is the fourth of a group who have been active in consultation in this field for over 20 years. Among the engineers may be mentioned WARREN J. TERRY at Somerville, Massachusetts, JOHN B. LITTLEFIELD at Chicago, the B & S Service, New York, and Pittsburgh Testing Laboratories. Ventilation engineers and vendors of ventilation equipment offer engineering services for control of occupational diseases. In describing his own work, DR. SAPPINGTON stated that medicolegal, labor relations and public relations take up the greater part of his present activity and continue to be important phases of the field of industrial hygiene.

Insurance Companies

MR. COOK pointed out that industrial hygiene services presented by the insurance companies were of two types. Most of the insurance companies offering compensation coverage include an engineering department. The men in these engineering departments have more or less extensive training and experience in occupational disease control. The second type of service rendered by a number of the leading compensation companies and certain of the group insurance companies embraces technical services in which are included industrial hygiene laboratories and field equipment together with trained staff for handling these activities. The following companies have such technical set-ups for conducting occupational disease evaluation and control: Aetna Life Insurance Company; American Mutual Liability Insurance Company; Bituminous Casualty Company; Fidelity & Casualty Company of New York; Employers' Liability Assurance Corporation, Ltd.; the Employers Mutuals of Wausau, Wisconsin; Liberty Mutual Company, Metropolitan Life Insurance Company, Michigan Mutual Liability Insurance Company, Travelers Insurance Company, and the Zurich Insurance Companies. These services undertake general surveys of plant conditions for occupational disease exposures, make specific studies of industrial health hazards which may present special problems, recommend control measures where necessary and make routine checks on conditions, usually with complete reports to the industry.

Industry

JOHN B. LITTLEFIELD: Your presence here is evidence that you are interested in industrial hygiene. The industrial hygienist in industrial work can be compared with the Chinese physician; unlike the gentlemen who have preceded me and who, for the most part are called in when the patient is already sick, the hygienist

working in industry is there to keep industry well. He is there to seek out potential trouble and provide corrective measures before harm is done. Although the value of industrial hygiene to industry has been proved for over a decade, and with industrial hygiene departments in such varied steel, glass, paint, rubber, chemical, electrical and mining industries, this service is thus far limited to those larger corporations having for the most part a number of plants. The small company with one or two plants and up to 500 or 1,000 men has not felt that it can afford such a service. However, the company of this size can no more afford to do without industrial hygiene than the large corporation. Here the risk is not spread over such a great amount of business, and a few unfortunate cases can cause serious loss, greatly exceeding normal, expected losses, either through direct payment or through increased cost of insurance due to the experience record. Smaller industries need this service; one way to get it is for a number of them, particularly where grouped closely together as in our Clearing District, to organize their own group service much as they now have a medical and hospital service in that area. Another answer is for more trained men to go into private work, taking on the responsibility for inspecting and advising a number of small industries. An experienced industrial hygienist can spot potential hazards in the small plant by quarterly or semi-annual visits, doing dust counts and air analyses where indicated, and by frank discussion with management of processes and materials in use or proposed. The main point is to have continuity of relations with an experienced hygienist who can become well acquainted with the particular industry. What can you expect industrial hygiene to do for you? First, it can improve working conditions. This is done by promoting good housekeeping, through plant surveys and inspections, by uncovering sources of harmful exposure to dust, fume, gases, skin irritants, dangerous light waves or noise, and by developing practical means of eliminating these exposures. The trained hygienist can recommend ventilation, either local or general, shielding, changes in processes, methods or materials, or personal protective equipment as best suits the situation. Experience has proved that such a program has a wide effect; where a better working environment has been provided industry has experienced better labor relations, reduction in illness, absenteeism and labor turnover, and the command of a better class of personnel. Right now foundries are experiencing a critical shortage of labor—the reason is not that the process is much less interesting than machining or forging but that foundries in general are way behind in cleaning up. Now that there are more jobs than men, the man seizes the opportunity to get out of dust, dirt and smoke. Sometimes

industrial hygiene pays an unexpected dividend in an improved product or lower cost of production. To cite a few instances, a drag dusting job in a mechanized molding operation exposed the drag finisher and those around him to a silicosis hazard; three remedies were apparent—to apply local exhausts, to change the material or to change the method of application. A combination of the last two, involving the spraying of an aqueous suspension of coal dust, was adopted. This reduced the dust concentration by 90%, the composition of the dust from $99+\%$ silica to almost nothing, and produced a better finish on the particular casting. Another example can be drawn from a small brass foundry where square welding (or brazing) rods, high in lead content, were ground on pedestal grinders with a serious exposure of the operators to lead dust. Increasing the exhaust only helped slightly as the steady rest, necessary for the work, caused a rebound of the stream of air created by the wheel. A change to a round rod and a centerless grinder, totally, enclosed and exhausted completely, eliminated the hazard and greatly reduced the cost of grinding these pieces. The second, and a very valuable service of industrial hygiene to industry, is to protect against and minimize compensation claims. An adequate industrial hygiene control program will catalog and evaluate the hazards present, enabling the company to eliminate those conditions which may lead to compensation cases. Records compiled regularly and showing conditions which exist now may prove invaluable later. Should a case develop this information will show whether or not it is justified. If it is shown by the record to be justified, it can be settled fairly and quickly without the ill feeling resulting from fighting a losing battle. On the other hand, if the records show the case to be without just cause, a clean fight can be waged with a good chance of success. There is nothing more embarrassing than to have to get up on the stand and say "we do not know what the conditions were when John Jones worked in our plant, but they are just about the same now and we find thus and so." How much better to be able to say "our industrial hygienist covered this job in three surveys during the time John Jones worked with us and found the conditions shown in these reports."

AFTER the conclusion of the presentations by the Panel Members, questions from the audience were discussed. As a result of this Panel Session, there is a much more complete understanding of the several industrial hygiene services available in the Greater Chicago area and of the place of each in this field. It was evident that these services are not competitive nor overlapping, but are supplementary, and that each fulfills its special functions in the broad scope included in industrial hygiene.

IRWIN, Medical Director, Aluminum Company of America, and DR. J. W. G. HANNON, Medical Director (U. S.), McIntyre Research, Ltd. (Toronto, Canada) on the subject "Aluminum Prophylaxis and Therapy in Silicosis." DR. IRWIN discussed "The Experimental Aspects," and DR. HANNON "The Clinical Aspects."

Michigan Section

ON JANUARY 17, 1945, the Michigan Section was addressed by DR. K. E. CORRIGAN, on the subject: "X-ray and Radium Hazards." DR. CORRIGAN discussed the increasing use of x-ray and radium in industry as well as in the medical and dental professions and the attendant accident and health hazards associated with their uses.

The Michigan Section program, held on February 28, was divided into three parts as follows: (1) Introductory remarks regarding the nature and toxicity of degreasing solvents by FRANK PATTY, Industrial Hygiene Consultant, General Motors, Research Laboratories Division. (2) A sound slide film in three parts on the design, operation and maintenance of degreasing equipment, prepared and shown through the courtesy of Detrex Corporation. (This was the premier showing of this educational film.)

At the meeting on March 28, WILLIAM G. FREDRICK, SC.D., Chief Chemist, Bureau of Industrial Hygiene, Detroit Department of Health, discussed "The Industrial Hygiene of Some Newer Organic Solvents and Volatile Liquids." Material presented by DR. FREDRICK included the uses, physical and chemical properties and toxicology of some ketones, organo-silicon compounds such as esters and silicones, nitro paraffins, higher alcohols, cellosolves, substituted benzenes such as xylene and cumene, dioxane, styrene and mesityl oxide.

Chicago Section

ON DECEMBER 28, 1944, DR. LEONARD WEBER, Dermatologist, addressed the Chicago Section on the subject "Industrial Dermatosis and Practical Methods of Prevention."

On January 25, the Chicago Section was addressed by MOHE SOLWORTH, of Louisville, Kentucky, on the subject: "Industrial Sanitation." PROFESSOR BURGESS H. JENNINGS, of Northwestern University School of Engineering, presented "Some Recent Developments in Aerosols."

The February 22, meeting was addressed by DR. CAREY P. McCORD, Medical Adviser Chrysler Corporation, on the subject "The Basophilic Aggregation Test in Lead Poisoning—Twenty Years After Its First Use."

On March 22, the Chicago Section was addressed by FRANCIS R. HOLDEN, PH.D., Industrial Hygienist, Industrial Hygiene Foundation of America, Pittsburgh, on "Occupational Diseases Occurring in Industries Today," and by C. O. SAPPINGTON, M.D., DR.P.H., Editor of INDUSTRIAL MEDICINE, on "Looking Ahead in Occupational Disease Developments."

American Industrial Hygiene Association News of Local Sections

Washington-Baltimore Section

THE first 1945 meeting of the Washington-Baltimore Section of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION was held Tuesday evening, February 27, 1945, at the Governmental Auditorium, Washington, D. C. Members of the Federal Interdepartmental Safety Council were guests of the Section at this meeting. Approximately 50 persons were present.

Discussing "The Role of Women in Industry," DR. ANNA M. BAETJER, of the Department of Physiological Hygiene, Johns Hopkins School of Hygiene and Public Health, and consultant to the Army Industrial Hygiene Laboratory, declared that much that is considered known about the health and working capacity of women workers is opinion rather than fact.

Metropolitan New York Section

AT THE meeting on February 21, a round-table discussion was held on "The Use and Hazards of Methyl Bromide in Industry." Representatives of different organizations discussed the industrial applications, health hazards, safe handling, and methods of detection in the light of their own experience. The discussion was most lively, and all were benefited greatly from the experience of others in this field. During the discussion,

it was emphasized particularly that the unbroken skin, itself, is the best protectant against the effect of this chemical. No rubber gloves should be used in the handling of this material. Likewise, no adhesive tape should be applied to the skin as long as the latter is in possible contact with methyl bromide. Early symptoms created by contact with methyl bromide may be mild; however, they may become more serious later on. The recovery may be slow and may take years.

A dinner meeting and round-table discussion was held at the Hotel Bristol, March 22, 1945. The subject for discussion was "Physical Methods—Measurement of Toxic Gases and Vapors in Air." Experts in the construction and use of the interferometer, ultra-violet and infra-red photometer, led the discussion.

Advance meeting dates schedule are as follows: May 10—afternoon meeting; September 3—round-table discussion; October 25—afternoon meeting; December 6—round-table discussion; annual meeting and election of officers.

St. Louis Section

THE first 1945 meeting of the Association was held Monday, February 12 at the York Hotel. The meeting was addressed by DR. DUDLEY A.

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